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A case report : compartment syndrome of the anterior thigh in a collegiate female

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A CASE REPORT:

COMPARTMENT SYNDROME OF THE ANTERIOR THIGH IN A COLLEGIATE FEMALE

A Project

Presented to

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of the Requirements for the Degree

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By

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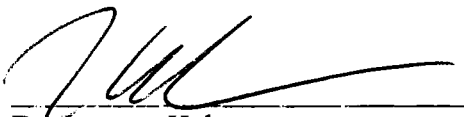

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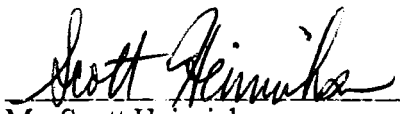

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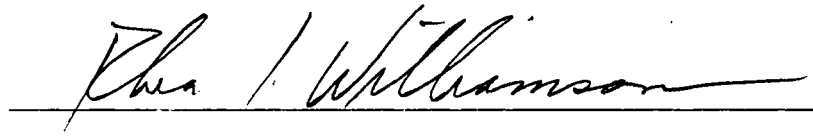

ABSTRACT

A CASE REPORT:

COMPARTMENT SYNDROME OF THE ANTERIOR THIGH IN A COLLEGIATE FEMALE

by Michelle C. Pikor

Chronic compartment syndrome of the anterior thigh is extremely difficult to diagnose based on symptoms. Primary symptoms are commonly misdiagnosed as iliotibial band syndrome, and treated conservatively. The purpose of this case study is to aid in educating sports medicine personnel to better evaluate and properly treat possible compartment syndrome of the anterior thigh by presenting a unique case in a collegiate female tennis player. The student athlete underwent surgical fasciotomy and six months of physical therapy before returning to tennis activities. Practitioners should be aware of chronic compartment syndrome as a possible cause of anterior thigh pain.

ACKNOWLEDGMENTS

I would like to thank the participant of this study for her support and enthusiasm for this study. A big thank you to Leamor, Dr. Conry, Carrie, and Scott for being such a strong committee. Thanks to Mike for bringing me into this experience. A very special thanks to my family and friends for supporting my studies thousands of miles away.

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CHAPTER 1

INTRODUCTION

Athletic trainers are responsible for the care and rehabilitation of athletic injuries. Student athletes have an increased demand to perform well in collegiate athletics, while athletic trainers have an increased demand to minimize injury recovery time. Therefore, immediate recognition and referral are important for prompt and accurate diagnosis. The purpose of this thesis is to provide sports medicine health care workers with a unique case of chronic compartment syndrome of the anterior thigh, from initial diagnosis, to post-surgical outcome.

The current thesis presents the signs and symptoms associated with chronic compartment syndrome of the anterior thigh in comparison to other commonly diagnosed overuse injuries of the thigh. The exact incidence of this injury is unknown possibly due to misdiagnosis or lack of recognition as a true injury of the thigh. The article component of the thesis explains complications that result from late or misdiagnosed compartment syndrome.

This thesis is divided into three chapters. Chapter 1 consists of the introduction, Chapter 2 contains the journal submission document, and Chapter 3 is the proposal document called extended support material.

In Chapter 2, the case study was written into a journal article for the *Journal of Athletic Training*, according to the *Author's Notes*. The *Journal of Athletic Training* provides a reliable resource to enhance the knowledge of certified athletic trainers. The journal provides the most current research and case studies to enhance the evaluative

process of injuries, and to maximize healing potential. The goal of this article submission is to increase awareness of this injury, facilitate early recognition, and ultimately benefit the playing status of the student athlete.

Chapter 3 consists of the extended support material used for the thesis proposal, which includes an introduction, review of literature, and the method. The introduction chapter defines the significance of the problem, the purpose, the limitations, the delimitations, and the definitions necessary for this thesis. The second chapter is a review of literature which contains all pertinent information including essential anatomy, compartment syndrome recognition, and treatment of this condition. The third chapter, methods, presents the participant, research design, and procedures of this thesis.

The goal of this thesis is to present a single case of chronic compartment syndrome of the anterior thigh. The article discusses the rarity of this syndrome and the potential for it to be misdiagnosed. The submission of this article to the *Journal of Athletic Training* will further enhance the knowledge of sports medicine professionals.

CHAPTER 2

JOURNAL SUBMISSION DOCUMENT

Compartment Syndrome of the Anterior Thigh in a Collegiate Female: A Case Report

Michelle C. Pikor; Leamor Kahanov; Barbara Conry; Scott Heinrichson

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Michelle C. Pikor, ATC, contributed to conception and design; acquisition and assembly of data; analysis and interpretation; drafting; critical revision; and final approval of the article. Leamor Kahanov, ATC, contributed; analysis and interpretation; drafting; critical revision; and final approval. Barbara Conry and Scott Heinrichson, ATC, contributed to analysis and interpretation of data; critical revision; and final approval of the article.

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Objective: The purpose of this case study is to aid in educating sports medicine personnel to better evaluate and properly treat possible compartment syndrome of the anterior thigh by presenting a unique case in a collegiate female tennis player.

Background: Chronic compartment syndrome of the anterior thigh is extremely difficult to diagnose based on symptoms. Primary symptoms are commonly misdiagnosed as iliotibial band syndrome, and treated conservatively. Practitioners should be aware of chronic compartment syndrome as a possible cause of anterior thigh pain.

Differential Diagnosis: Anterior thigh compartment syndrome versus iliotibial band syndrome.

Treatment: The injury was initially treated conservatively with NSAID's, modalities, stretching and ice. Follow-up consisted of X-ray, MRI, EMG, neurological evaluation and compartment pressure testing. The athlete was diagnosed with compartment syndrome of the anterior thigh and underwent bilateral fasciotomy surgery.

Uniqueness: The surgery will determine the effectiveness of bilateral fasciotomy on the anterior thigh compartment of a Division I female collegiate tennis player. The study will provide insight on symptoms, surgical treatment and the rehabilitative outcome of this procedure.

Conclusions: Sports medicine personnel should be aware of the symptoms and evaluation techniques associated with chronic compartment syndrome of the anterior thigh. Early detection will decrease injury time, and enhance a future in athletics.

Key Words: Fasciotomy, Ischemia, Iliotibial band

INTRODUCTION

Chronic compartment syndrome is the inadequacy of the musculofascial compartment size resulting in chronic or reoccurring pain and disability.[1] Circulation and function of the tissues in that space are compromised.[2] Incidence of chronic compartment syndrome of the anterior thigh compartment is extremely rare, yet if left untreated, localized ischemia can lead to necrosis.[3]

Once the affected muscles in chronic compartment syndrome have hypertrophied significantly to increase pressures beyond a tolerable level, a chronic problem will persist.[1] Severe consequences of undiagnosed or misdiagnosed chronic compartment syndrome, including muscle ischemia and cell necrosis, emphasize the importance of early recognition and prompt referral to a physician. The exact degree of irreversible tissue damage is unknown, however, patients with pre-surgical abnormal muscle biopsies may not fully recover from surgical fasciotomy.[1]

Delayed diagnosis of chronic compartment syndrome of the anterior thigh may contribute to the loss of an athletic season, or an athletic career. The recognition and care of athletic injuries is essential and often the first in line medical care for athletes, therefore, proper evaluation and treatment of chronic compartment syndrome of the anterior thigh is essential.

CASE REPORT

A 20-year-old, five-foot eight-inch, 137-pound, collegiate female tennis player presented to the training room with pain in both lateral thighs. A thorough history revealed that the student athlete noticed pain in both thighs halfway through the season, but she assumed she was naturally sore from an accumulation of practice and long tennis matches throughout the year. Three days prior to the evaluation, she played a tennis match that created significant pain along both distal iliotibial bands. The exact mechanism was non-specific, but the she mentioned playing on her toes throughout the match because of heel pain, which increased the demand to her thighs. The student athlete described the thigh pain as sharp, from the origin to the insertion of the iliotibial band. The athletic trainer documented palpable tenderness over the iliotibial bands and a positive Ober's test bilaterally. All other special tests were negative. The student athlete was immediately referred to the team physician and diagnosed with bilateral iliotibial band syndrome. The initial week of treatment consisted of complete rest from tennis activities, NSAID's, moist heat, stretching, soft tissue massage, foam roller and cold whirlpool.

The student athlete completed the last three matches of the 2004 spring season in pain, one week after the initial injury. Upon a post-season evaluation, both thighs presented increased flexibility but continuous pain along the iliotibial bands with deep palpation. The student athlete took five weeks off from all activities to recover. Six weeks after the initial injury, the student athlete returned to the athletic training room with no decrease in symptoms. She was immediately referred to the team physician. An MRI omitted the possibility of bilateral stress reactions, however displayed inflammation with fluid between the iliotibial band and the lateral femoral condyle of both knees. An injection of 2 mg of soluble Decadron and 40 mg of Kenalog in 3 cc of 0.5 percent Mar-

caine was administered to both thighs to relieve inflammation. Two months after the initial injury, the student athlete returned home to begin physical therapy. The athletic trainer maintained communication with the student athlete bi-monthly during summer vacation for the next two months.

During the first month of physical therapy, the student athlete was restricted from exercise activity while focusing on stretching and strengthening. Exercises included manual resistive exercises to strengthen the quadriceps, hamstrings, gluteals, and lower legs. She mentioned relief of pain but reported feeling weak in the quadriceps muscles. Upon pain relief, the elliptical and stairmaster were added to the regime, and in one day, student athlete re-aggravated both iliotibial bands. Three months after the initial injury the student athlete left for a three-week trip to Europe. During that time, her daily exercise consisted of walking and use of a foam roller for flexibility. However, the pain continued to increase in both legs. The student athlete communicated to the team athletic trainer regarding palpable stiffness in the distal lateral quadriceps, and a new symptom, night pain. The student athlete did not return to physical therapy for the next week.

Four months after the initial injury the student athlete returned to the university for follow up with the team physician. The team physician documented complaints of pain and tenderness along the iliotibial band with both activity and rest. No pathology in the knees or hips were found. The student athlete was referred to a second physician for compartment pressure measurements in both thighs. Pre-exercise compartment measurements of the thighs in this student athlete exceeded upper limits of normal levels. Compartment

Figure 1. 3-cm incision to right thigh

pressures were measured using an intracompartment pressure monitor. The student athlete noted an inability to continue exercise because it created symptoms in the left thigh as well as marked pain in the right thigh. The physician noted that the student athlete's symptoms and measurements were consistent with compartment syndrome.

Five months after the initial injury, the student athlete was referred to the team physiatrist for a second opinion. The student-athlete reported intermittent symptoms of numbness in the distal thighs from elevating her legs, sitting, or standing up. She had no complaints of back, hip, buttock, posterior thigh, or posterior calf pain. The team physiatrist found no evidence of neurological syndrome, and agreed with the findings of compartment syndrome of the anterior thigh. The student athlete underwent bilateral fasciotomy the following day.

Five months after the initial injury the student athlete underwent bilateral surgical fasciotomy of the anterior thigh compartment. The surgery consisted of 3-cm incisions in the distal thighs just anterior to the iliotibial band (Figure 1). Metzenbaum scissors were used to release the fascia. The fascia was incised from the superior

aspect of the patella in line towards the anterior aspect of the greater trochanter. The incision measured 22-cm from the superior pole of the patella (Figure 2).

Post-surgery, as per instructed by the operating physician, the student athlete progressed from five days in a wheelchair to eight days of progressive crutch walking to full weight-bearing. Physical therapy exercises began nine days post-surgery. Initial therapy consisted of stretching, balance training, gait training, and non-weight bearing strengthening exercises. Exercises included bike for range of motion, quad sets, heel slides, straight leg raises, 4-way hip pulley exercises, seated leg extensions, and supine bridging. As flexibility and gait improved over the next five days, balance, calf raises, and shuttle leg press were added. Three and four weeks post-surgery, closed chain therapy exercises were added. Exercises included hip hikes, mini-squats, mini-lunges, and balance exercises on a wobble board. Manual therapy consisted of hip D1 and D2 patterns, knee flexion and extension, and ankle PNF. During the first four week period, the student athlete was unable to perform side-lying exercises due to discomfort along the lateral thighs.

Week five and six post-surgery, the student athlete continued to advance leg and gluteal strength and progressed to a treadmill walking program. Exercises included, quadruped leg extension, lateral steps with tubing, clams, and wall sits. Manual exercises included the addition of hamstring curls, knee flexion and extension, prone ankle plantarflexion, and squats. Weeks seven and eight focused on increasing strength with current exercises while increasing cardiovascular endurance on the bike. Shuttle jumps and mini-tramp jogging were added to begin a progression to a jogging program. Within the first two

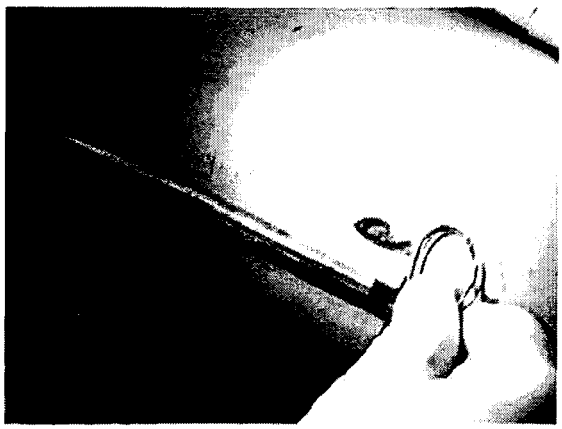

Figure 2. Fasciotomy of right anterior thigh compartment

months of therapy, the student athlete reported intermittent muscle soreness, described as "good soreness." Over the next month, the student athlete advanced to the elliptical and progressed to a treadmill jog while continuing to increase strengthening exercises. The team physician cleared her to increase activity as tolerated.

Three months following fasciotomy, a treadmill jog increased muscle tension, iliotibial band tightness, and throbbing pain. The student athlete resumed physical therapy in southern California over the winter break period. Exercises involved an initial decrease in strength work while focusing on stretching and endurance with the previous strength exercises. Activity was decreased because muscle tension continued to increase and throbbing pains disrupted sleeping patterns. Four months post-surgery, follow-up compartment pressure measurements were indicated due to a reoccurrence of symptoms. The physician noted tenderness and loss of range of motion in both iliotibial bands. No neurological symptoms were noted. The anterior thigh compartments pre-exercise measured 10 mmHg and 9 mmHg for the right and left compartments respectively. Post-

exercise the right compartment measured 22 mmHg and the left 14 mmHg. The right thigh was within the upper limits of normal pressure and the left thigh was within normal limits. Upper limits of normal compartment pressures are approximately 15 mmHg or less, however, surgical fasciotomy is not typically indicated if pressures are below 30-35 mmHg.[1] The recommended plan was to continue physical therapy and return to activities as tolerated.

Physical therapy resumed immediately with an emphasis on stretching and endurance training. Exercises focused on iliotibial band flexibility, TFL positional release techniques, ankle PNF, hamstring curls, swimming, and aqua jogging. The team physician prescribed a seven day tapered course of prednisone that relieved the tension in both iliotibial bands, however, pain returned one week later. The student athlete progressed through initial strengthening exercises for the next month. Five months post-surgery, stiffness returned to both legs and the student athlete was referred for a second opinion. The physician was not convinced the student athlete had iliotibial syndrome. An X-ray, MRI, and an EMG study were ordered and referred for review by the team physiatrist. The student athlete also noted tingling in both legs along the peroneal nerve distribution. The EMG and X-ray were normal. Exercises progressed from endurance to strengthening with the addition of core stabilization techniques. Manual resistive exercises included D1 and D2 hip PNF, ankle PNF, hamstring curls, hip abduction/adduction, and squats. Other exercises included bridging, calf raises, shuttle leg press, lunges, squats, and wall sits. MRI of the lumbar spine revealed a small central protrusion of the L5-S1 intervertebral disc with a posterior midline annular fissure. Six months post-surgery, the student athlete had a left and right S1 transforaminal selective epidural block. She immediately left for the spring break period. Upon return from break, 10 days post-injection, the athlete noticed a relief of pain and tension in the iliotibial bands. The team physiatrist recommended continued strengthening exercises in addition to light hitting on the tennis court. The student athlete is continuing to return to full participation in collegiate tennis. She will return for the following academic year sport season.

DISCUSSION

The muscles of the anterior thigh compartment are the sartorius, vastus medialis oblique, vastus lateralis oblique, vastus intermedius, rectus femoris, and the tensor fascia lata. The fascia of the thigh consists of deep and superficial layers.[4] The subcutaneous tissue contains fat, blood vessels, lymph vessels, and cutaneous nerves. The fascia lata thickens to form the iliotibial tract, creating immense strength laterally.[4] Decreased flexibility of the lateral aspect of the anterior thigh compartment increases the susceptibility of compartment syndrome. The student athlete in this case displayed painful and palpable increases in stiffness to the distal lateral thighs.

The exact incidences of compartment syndromes are unknown. Most patients with chronic compartment syndrome are in their early 20's and are engaged in endurance activities; with males and females affected equally.[5] The exact reason for an increased occurrence at this age is unknown, but may be considered within prime endurance years, or related to an in-

crease in activity during the transition from high school sports to the demands of collegiate athletics. Patients typically experience symptoms bilaterally with one limb experiencing equal or increased symptoms.[1] A considerable number of patients feel relief of symptoms by decreasing activity that causes irritation, an explanation as to why this syndrome may be under diagnosed. Similar to the literature, the student athlete noted a reduction in symptoms during the initial three months of therapy; as weight bearing activities increased and symptoms typically return.

During exercise, capillary surface area and pressure increase without a linear increase in reabsorption, resulting in increased muscle volume.[5] Fluid pressure increases within the compartment eventually compress the muscles, blood vessels, and nerves.[6] When tissue fluid pressures exceed capillary profusion pressure, the capillaries collapse and the tissues within the compartment become ischemic.[7] After exercise, fluid pressures fall below capillary profusion pressures and symptoms subside. In a study by Orava, a muscle biopsy of the vastus lateralis from two patients showed signs of superficial muscle cell necrosis with Magnetic Resonance Imaging (MRI). [3] In both cases, the muscle regained original form three months after fasciotomy.[3] Permanent damage from muscle ischemia can be prevented with early detection. The student athlete in this case did not show signs of cell necrosis on MRI.

A thorough history and evaluation may reveal symptoms specific to compartment syndrome. The student athlete will note improvements in symptoms during periods of rest and experience a reoccurrence of symptoms following exercise.[5] The student athlete will typically display normal pulses, capillary filling, range of motion, full strength, and normal reflexes upon evaluation.[5] Common treatment options such as rest, ice, compression, elevation, and non-steroidal anti-inflammatories provide little benefit to athletes with chronic compartment syndrome.[7] Ninety percent of patients experience bilateral symptoms in the corresponding compartment of the opposite extremity.[5] Ischemia and neurological deficits are highly uncommon in chronic compartment syndrome.[8]

The student athlete for this study displayed symptoms of pain and weakness in both thighs. MRI of the thighs showed no signs of cell necrosis or stress fracture, however, symptoms continued to increase, even at rest. Further evaluation warranted compartment pressure testing. An athlete with chronic compartment syndrome will typically feel no pain at rest, but with exercise, pain and symptoms develop.[8] In most cases, X-ray, MRI, and bone scan may all be inconclusive. However, MRI may show atrophy of the muscles if compared before and after exercise.[3] In most cases, compartment pressure testing establishes a definitive diagnosis, and can be measured with either a catheter wick or saline needle technique.[5] Neurological deficits, tenderness, and pressure measurements of the compartment should be monitored before and after the exercise test.[7] Fourteen millimeters of mercury is considered the upper limit of normal tissue pressure at rest. Pressures, after exertion, ranging between 15 and 30 mm Hg are diagnosed within normal limits; and pressures greater than 30-35 mm Hg should be treated immediately.[5] Patients below the upper pressure limits who present symptoms of chronic compartment syndrome may benefit from surgical fasciotomy.[5] Indications for surgical fasciotomy should

be specific to the patient's symptoms. Post-exercise compartment pressures of the student athlete in this study were recorded initially as 46 mmHg and 16 mmHg, and post surgically 22mmHg and 14 mmHg of the right and left compartments respectively (Figure 3). Resting pressures exceeded capillary profusion levels, and therefore explained why the student athlete was symptomatic at rest.

Because of the large potential space in the anterior thigh, compartment syndrome is rare.[9] Physical examination of chronic compartment syndrome is frequently unremarkable, especially if the patient is asymptomatic at the time of examination.[5] Patient history may describe pain with exercise, and worsening of symptoms as the sporting season elapsed. Patients may present symptoms of overuse injuries, for example, iliotibial band syndrome, vastus lateralis strain, stress fracture, or peroneal nerve irritation. Symptoms may gradually increase, even with conservative treatment. Exercise testing should be specific to the activity that presents symptoms. Tightness of the compartment by palpation may be present if pressures exceed 30-35 mmHg.[1] The student athlete in this case had palpable stiffness in both distal lateral anterior thigh compartments. However, low values have not been accepted as determinants for the need of surgical decompression.[2] The left anterior thigh compartment pressure in the student athlete was 14 mmHg post-exercise, but she presented symptoms similar to that of the right leg which measured 46mmHg, therefore, the team physician proceeded with bilateral fasciotomy. Hutchinson describes seven symptoms that may present with compartment syndrome, which he refers to as the seven P's.[9] These symptoms include: pain, pressure, pain with stretch, paralysis, paraesthesia,

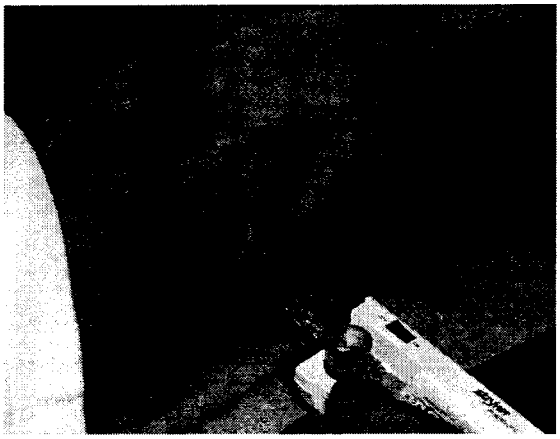

Figure 3. Compartment pressure measurement of the right anterior thigh compartment

diminished pulses, and pallor. Symptoms of chronic compartment syndrome of the anterior thigh present symptoms similar to that of compartment syndrome of the lower leg. Patients with chronic exertional compartment syndrome of the anterior thigh may experience some, if not all, of the symptoms listed previously. Prior to surgical fasciotomy the student athlete in this case noted bilateral pain, pressure and paraesthesia, consistent with previous research.

The diagnosis of chronic compartment syndrome of the anterior thigh should be based upon a complete evaluation. The student athlete studied had an immediate physician referral, overuse injuries were ruled out with MRI, and compartment pressures were measured as symptoms increased. A detailed history of symptoms with the associated treatments that have either succeeded or failed will help the sports medicine personnel explore compartment syndrome as a possibility. Further diagnostic testing will determine whether compartment syndrome was the proper diagnosis.

Symptoms of chronic compartment syn-

drome vanish during conservative treatment, but return as normal training routines are resumed.[3] Athletes who exceed tolerable levels must proceed with surgical fasciotomy. Fasciotomy is the definitive treatment for chronic compartment syndrome, in which the orthopedic surgeon will open the affected compartment layers with a full fasciotomy or partial fasciotomy to decrease compartment pressure.[5] The student athlete's symptoms initially ceased with activity, however, a threshold was exceeded and pain became throbbing and continuous throughout the day. A fasciotomy, in this case, was indicated immediately, as supported by experts in the field.[3,5]

The only conservative alternative to fasciotomy for chronic compartment syndrome is to decrease participation in sports.[8] Non-surgical treatment may consist of physical therapy, orthotic devices, stretching programs, and diuretic use, providing little benefit to the patient.[5] In the highly competitive sporting arena, cessation of activity may not be an option. The student athlete in this case was able to return to tennis activities five and a half months after surgical fasciotomy. The student athlete then experienced a set back, a small central protrusion of the L5-S1 intervetebral disc, which delayed full return to tennis activities. The relationship between the student athlete's disc protrusion and the onset of compartment syndrome is unknown. The disc protrusion may have occurred prior to the onset of compartment syndromes, or as an unrelated injury. A need for more research on the relationship of low back injuries and compartment syndrome is warranted. The team physicians were unable to determine if the injury to the disc occurred prior to, or as a result of, compartment syndrome to the anterior thigh. Athletic trainers and physical therapists must understand the signs and symptoms related to compartment syndrome of the anterior thigh, and the possibility of other pathologies, in order to facilitate a quick and healthy return to sport.

CONCLUSIONS

Sports medicine personnel must be well trained in the assessment of injuries to the thigh. Thorough knowledge of the anatomy of the thigh, the compartment properties, and the symptoms associated with compartment syndrome are essential evaluative components of an accurate assessment of anterior thigh compartment syndrome. Once compartment syndrome is suspected, the student athlete should be referred to a physician and fasciotomy should be performed for relief of symptoms.[5] In addition, further diagnostic testing and future research is necessary to determine if a relationship exists between low back pain, iliotibial syndrome, and compartment syndrome. Post-surgical treatments must be based upon individual needs. Sports medicine personnel must stay current with new medical diagnoses and procedures. Anterior thigh compartment syndrome can lead to permanent cell necrosis and the potential for a loss of a season or an athletic career. Therefore, the purpose of this study is to educate sports medicine personnel in the evaluation and treatment of compartment syndrome of the anterior thigh.

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CHAPTER 3

EXTENDED SUPPORT MATERIAL

SECTION 1

INTRODUCTION

Chronic compartment syndrome is a result of increased pressured within a fixed space that compromises circulation and function of tissues in that space (Matsen, Winquist, & Krugmire, 1980). Incidence of chronic compartment syndrome of the thigh is extremely rare, yet if left untreated, localized ischemia can lead to cell necrosis (Orava, Laakko, Matilla, Makinen, Rantanen, & Kujala, 1998). Within a 13-year period, a sports trauma research unit in Finland surgically treated only 9 patients with chronic compartment syndrome of the quadriceps (Orava, 1998). The familiarity of symptoms to that of more commonly treated thigh injuries supports the possibility that compartment syndrome of the anterior thigh is under-diagnosed; however, the frequency of referrals increase yearly, proving compartment syndrome to be uncommon, yet not rare (Detmer, Sharpe, Sufit, & Girdley, 1985). Due to the rarity of chronic compartment syndrome in the thigh and the severe disability associated with a lack of treatment, the purpose of this project is to detail one case study of bilateral chronic exertional compartment syndrome of the anterior thigh in a Division I collegiate female tennis player.

Chronic compartment syndrome is described as the inadequacy of the musculofascial compartment size (the compartment is too small for the size of the contents including muscle, blood vessels, and nerves), resulting in chronic or reoccurring pain and disability (Detmer, Sharpe, Sufit, & Girdley, 1985). The increase in Compartment pressure compromises circulation to the muscle and nerve tissue within that space (Lutz, Goodenough, & Detmer, 1989). Compartment syndromes typically

affect young athletes whose primary symptoms include tightness and achy pain that begins with activity and ends after a varying length of time after exercise ceases (Lutz, 1989).

Symptoms of compartment syndrome may be too variable to create an early diagnosis since physicians must first rule out the possibility of overuse syndromes, neurological injuries, or time to decipher the description of the patient's symptoms (Matsen, Winquist, & Krugmire, 1980). Some patients may experience neuromuscular deficits while the majority do not. Matsen, Winquist, & Krugmire (1980), describes symptoms for diagnosis as pain unsupported by a mechanism, pain and weakness on stretch, hypoesthesia of the distribution of the compartment, and palpable tightness along the fascial boundaries. Symptoms of chronic compartment syndrome cease after exercise activity, therefore, delaying the diagnosis and treatment (Strauss, 2002). As the condition persists, sustained elevation of pressure within the compartment promotes thickening of the fascia resulting in an increase in chronic pain (Lutz, Goodenough, & Detmer, 1989).

Detmer, Sharpe, Sufit, & Girdley (1985) suggest that once the affected muscle has hypertrophied significantly to increase pressures beyond a tolerable level, the chronic problem will persist. Symptoms of chronic exertional compartment syndrome that persists for greater than three to six months may benefit from surgical fasciotomy (Hutchinson & Ireland, 1994). Assuming blood pressure, neurological, and peripheral vascular systems are normal, indications for surgery are ultimately dependent upon pressure measurements associated with signs and symptoms. Patients with chronic compartment syndrome are expected to return to full activity, without limitation, after

fasciotomy surgery. The only successful non-surgical treatment is to decrease all exercise activities.

Due to the severe consequences of undiagnosed or misdiagnosed chronic compartment syndrome, which include muscle ischemia and cell necrosis, the emphasis of early recognition and prompt referral to a physician is essential. Allied health care workers such as athletic trainers, physical therapists, physician assistants, nurses, or others are responsible for evaluating and referring athletes to the team physician and should pay particular attention to potential symptoms of chronic compartment syndrome. Early recognition of this condition as a possible syndrome can decrease the time elapsed for diagnosis and thus potential morbidity. Therefore, the purpose of this project is to present the signs and symptoms associated with chronic compartment syndrome of the anterior thigh. In addition, providing this information may aid sports medicine health care workers in acquiring knowledge regarding chronic compartment syndrome of the anterior thigh.

Significance of the Problem

The current project explores the symptoms, pathologies, and treatments associated with compartment syndrome of the anterior thigh. The symptoms are similar to that of overuse injuries; however, conservative treatments have proven unsuccessful as symptoms return as normal training is resumed (Orava, Laakko, Matilla, Makinen, Rantanen, & Kujala, 1998). Physical exertion increases pressures within the compartment, placing the student athlete at risk for local ischemia. Ischemia is the restriction of blood flow to the muscles and nerves because of the extreme pressures

within the compartment. Early diagnosis of local muscle atrophy and ischemia can be eliminated with surgical fasciotomy (Orava, 1998). However, a delay in diagnosis increases the potential of permanent local muscle cell necrosis or nerve damage (Hutchinson & Ireland, 1994). Detmer, Sharpe, Sufit, & Girdley (1985) found patients with pre-surgical abnormal muscle biopsies that did not fully recover after surgical fasciotomy, however, the exact degree of irreversible tissue damage remains unknown. Tissue necrosis of the anterior thigh compartment can be prevented with early diagnosis, fasciotomy and rehabilitation.

Statement of Purpose

Therefore, the purpose of this project is to present the signs and symptoms associated with chronic compartment syndrome of the anterior thigh. In addition, providing this information may aid sports medicine health care workers in acquiring knowledge regarding chronic compartment syndrome of the anterior thigh. This case study will be compiled into an article and submitted to the *Journal of Athletic Training* according to the journal's submission policies (see Appendix A).

Delimitations

This case study is delimited to a single Division I collegiate female tennis player who developed chronic bilateral compartment syndrome of the anterior thigh. The onset of symptoms was relatively acute and initially diagnosed as iliotibial band syndrome. After several months of persistent symptoms, the student athlete was tested for bilateral compartment pressures. The student athlete was further diagnosed with compartment syndrome of the anterior thigh and underwent a bilateral fasciotomy.

Limitations

The limitations of this study include:

1. The inability to control environmental effects of the case
2. The inability to be present at the onset of symptoms may limit the researcher's ability to interpret data as it was originally recorded.

Definitions

The following terms are defined for the purpose of this study

Acute Injury: Sudden onset of injury due to a specific mechanism

Allied Health Care Provider: Person responsible for the health and well being of each patient.

Anterior: The front of the body

Athletic Trainer: A health care professional certified by the National Athletic Trainers Association Board of Certification (BOC) specializing in the prevention, assessment, treatment and rehabilitation of athletic injuries and illnesses.

Chronic Injury: Injury as a result of repetitive trauma

Compartment: Fascial sheath that surrounds a muscle or muscle group

Compartment Syndrome: Compromised space within the confines of the fascia that compresses the muscles, blood vessels and nerves.

Fasciotomy: Surgical procedure in which the fascia is cut to relieve the pressure within the compartment

Physiatrist: A non-surgical physical medicine physician

Sports Medicine Professional: A member of the sports medicine team who performs specific functions in caring for an injured athlete.

Student Athlete: An individual participating in a varsity level sport at a scholastic institution.

Thigh: The area of the leg located between the hip and the knee.

Summary

The rarity of chronic compartment syndrome delays early diagnosis and treatment, and can lead to local muscle ischemia and cell necrosis. The purpose of this study is to present a case study of a collegiate tennis player who experienced complications from chronic compartment syndrome of the anterior thigh, and to present an unusual case to further the understanding of the athletic training field. Her inability to continue the spring season necessitated further testing for an exact diagnosis and indication for surgery.

The continuation of education on new topics in the field of sports medicine is essential to enhance the evaluation and treatment of rare injuries. Due to the rarity of bilateral compartment syndrome of the thigh, sports medicine professionals must be educated in the recognition of chronic compartment syndrome of the anterior thigh. This case study will be submitted to the *Journal of Athletic Training* for publication.

SECTION 2

REVIEW OF LITERATURE

This chapter will provide a literature review, in seven sections, related to anterior thigh compartment syndrome, including: case study characteristics, anatomy of the thigh, anterior thigh compartment properties, incidence of compartment syndrome, chronic compartment syndromes, treatment of compartment syndrome, and anterior thigh compartment syndrome recognition. The first section reviews the methodology behind the creation of a case study. The anatomy section provides general information on the structures of the thigh. The next section, anterior thigh compartment properties, will detail the components of the area being studied. The incidence section will discuss common compartment syndromes currently diagnosed in athletics. The next section will review the signs and symptoms associated with chronic compartment syndrome, the focus of this case study. The sixth section will review the treatment of chronic exertional compartment syndrome and the indications for surgery. The final section will discuss symptoms of compartment syndrome specific to the anterior thigh.

Case Study Characteristics

A case study is a detailed description of a single case to form a greater understanding of similar cases (Thomas & Nelson, 2001). A descriptive study presents a detailed picture of a single phenomenon for the purpose of achieving a better understanding of the phenomenon (Thomas, 2001). Data collection of a case study should include; patient history, chief complaint, medical history, physical examinations, doctor's notes, diagnosis, treatments, and outcomes (Ingersoll, 2001). The information

gathered from a single case provides insight and knowledge to improve the practices of allied health care workers (Thomas & Nelson, 2001).

The present case satisfies all of the above characteristics by focusing on one student athlete with chronic compartment syndrome of the anterior thigh and a unique description of events that will further the knowledge of sports medicine personnel.

Anatomy of the Thigh

The thigh is divided into three distinct compartments; anterior, posterior, and medial. Each compartment is surrounded by fascia, a fibrous inelastic tissue that supports and protects the muscle, vessels, and nerves (Lavin, 1989). The anterior compartment consists of hip flexors and knee extensors, the posterior compartment is made up of hip extensors and knee flexors, and the medial compartment consists of the hip adductors. According to Hutchinson & Ireland (1994), the anterior compartment includes the quadriceps muscles, sartorius, and the tensor fascia lata.

Anterior Thigh Compartment Properties

The muscles of the anterior thigh compartment are the sartorius, vastus medialis oblique, vastus lateralis oblique, vastus intermedius, rectus femoris, and the tensor fascia lata. The fascia of the thigh consists of deep and superficial layers (Moore & Agur, 2002). The subcutaneous tissue contains fat, blood vessels, lymph vessels, and cutaneous nerves. The deep fascia lies between the subcutaneous tissue and the muscle, within the thigh, and is referred to as the fascia lata (Moore, 2002). The fascia lata attaches to the superior aspect of the inguinal ligament, pubic arch, body of pubis, and pubic tubercle, expanding to the lateral and posterior iliac crest and posterior to the sacrum, coccyx,

sacrotuberous ligament, and ischial tuberosity (Moore, 2002). The fascia lata thickens to form the iliotibial tract, creating immense strength laterally (Moore, 2002). Decreased flexibility of the lateral aspect of the anterior thigh compartment increases the susceptibility of compartment syndrome.

Incidence of Compartment Syndrome

The exact incidences of compartment syndromes in the general population and in student athletes are unknown. Most patients with chronic compartment syndrome are in their early 20's and are engaged in endurance activities; males and females affected equally (Lutz, Goodenough, & Detmer, 1989). Most patients experience symptoms bilaterally with one limb experiencing equal or increased symptoms (Detmer, Sharpe, Sufit, & Girdley, 1985). A considerable number of patients feel relief of symptoms by decreasing activity that causes irritation, an explanation as to why compartment syndrome may be under diagnosed.

Chronic Compartment Syndromes

Compartment syndromes can be divided into two types: acute or chronic. Both types increase the pressures within the compartment (Hutchinson & Ireland, 1994). The first type, acute compartment syndrome, is traumatic in nature. Acute compartment syndrome can occur from rhabdomyolysis or a direct blow. Rhabdomyolysis, as a result of excessive exercise, is the breakdown of muscle tissue that causes the intracellular contents to leak into the blood. Symptoms include progressive burning over the effected muscles, urine brown in color and extreme pain with range of motion (Wise & Fortin,

1997). Mechanisms that cause compartment pressures to rapidly exceed 30 mmHg are defined as acute.

Chronic compartment syndrome differs from acute compartment syndrome in that the symptoms cease when activity has ended (Strauss, 2002). During exercise, fluid pressure increases within the compartment and compresses the muscles, blood vessels, and nerves (Arnheim & Prentice, 2000). During exercise, capillary surface area and pressure increase without a linear increase in reabsorption, resulting in increased muscle volume (Lutz, Goodenough, & Detmer, 1989). When tissue fluid pressure exceeds capillary profusion pressure, the capillaries collapse and the tissues within the compartment become ischemic (Strauss, 2002). After exercise, fluid pressures fall below capillary profusion pressures and symptoms subside. Decompression of acute compartment syndrome is indicated for prevention of muscle ischemia. In a study by Orava, Laakko, Matilla, Makinen, Rantanen, & Kujala (1998), a muscle biopsy of the vastus lateralis was taken in two patients who showed signs of superficial muscle cell necrosis with Magnetic Resonance Imaging (MRI). In both cases, the muscle regained original form 3 months after fasciotomy (Orava, Laakko, Matilla, Makinen, Rantanen, & Kujala, 1998). Severe cases of avascular necrosis may be rare because of the inability of the athlete to fully participate through the pain.

A thorough history and evaluation may reveal symptoms specific to compartment syndrome. The student athlete will note improvements in symptoms during periods of rest and reoccurrence following exercise (Lutz, Goodenough, & Detmer, 1989). The student athlete will typically display normal pulses, capillary filling, range of motion,

strength and reflexes upon evaluation (Lutz, 1989). Common treatment options such as rest, ice, compression, elevation, and non-steroidal anti-inflammatories provide little benefit to athletes with chronic compartment syndrome (Strauss, 2002). Ninety percent of patients experience bilateral symptoms in the corresponding compartment of the opposite extremity (Lutz, Goodenough, & Detmer, 1989). Ischemia and neurological deficits are highly uncommon in chronic compartment syndrome (Hutchinson & Ireland, 1994).

In chronic compartment syndrome, the athlete will feel no pain at rest but with exercise pain and symptoms develop (Hutchinson, 1994). In most cases, X-ray, MRI, and bone scan may all be inconclusive. However, in a few cases, MRI may show atrophy of the muscles if compared before and after exercise (Orava, Laakko, Matilla, Makinen, Rantanen, & Kujala, 1998). In most cases, compartment pressure testing can be measured with either a catheter wick or saline needle technique (Lutz, Goodenough, & Detmer, 1989).

Neurological deficits and tenderness of the compartment should be monitored before and after the stress test (Strauss, 2002). Fourteen millimeters of mercury is considered the upper limit of normal tissue pressure at rest. Pressures, after exertion, ranging between 15 and 30 mm Hg are diagnosed within normal limits, and greater than 30-35 mm Hg should be treated immediately (Lutz, Goodenough, & Detmer, 1989). Patients below the upper limit who present symptoms of chronic compartment syndrome may benefit from surgical fasciotomy (Lutz, 1989). Indications for surgical fasciotomy should be specific to the patient's symptoms.

The lower leg is the most commonly diagnosed of compartment syndromes. Though common, chronic compartment syndrome of the lower leg is commonly misdiagnosed as medial tibial stress syndrome. Early diagnosis of chronic compartment syndrome is rare because of conservative treatment routes. Symptoms include pain with passive stretching, numbness in the distribution of the transversing nerves, muscle weakness, and throbbing pain in the lower leg during exercise (Strauss, 2002). The compartments of the lower leg include the anterior, lateral, posterior superficial medial, posterior superficial lateral, posterior deep proximal, posterior deep distal, and posterior superficial distal (Detmer, Sharpe, Sufit, & Girdley, 1985).

A quadriceps contusion is the most common form of acute compartment syndrome of the thigh. Acute injuries to the thigh are frequently treated with conservative measures and pressure monitoring (Hutchinson & Ireland, 1994). Larger compartments allow for greater volume expansion and increased swelling to reach critical pressures (Colosimo & Ireland, 1992). Because of the large potential space in the anterior thigh, compartment syndrome is believed to be rare (Kahan, McClellan, & Burton, 1994). The anterior thigh compartment has the stiffest walls laterally and medially, and because of its location and vulnerability to contusion, is the most reported of compartment syndromes (Kahan, 1994).

The diagnosis of chronic compartment syndrome of the anterior thigh should be based upon a complete evaluation. A detailed history of symptoms with the associated treatments that have either succeeded or failed will help the sports medicine personnel explore compartment syndrome as a possibility. A student athlete with chronic

compartment syndrome of the anterior thigh will present symptoms similar to that of compartment syndrome of the lower leg. Further diagnostic testing will determine whether compartment syndrome is the proper diagnosis.

Treatment of Compartment Syndrome

Acute compartment syndrome of the thigh may be treated conservatively, however, must be monitored for complications. Severe acute compartment syndrome requires surgical fasciotomy. Conservative treatments consist of rest, modalities, massage, and stretching. Athletes who are treated conservatively are able to return to activity within 3-8 weeks. Typically, symptoms of chronic compartment syndrome vanish during conservative treatment, but return as normal training routines are resumed (Orava, Laakko, Matilla, Makinen, Rantanen, & Kujala, 1998). Athletes who exceed tolerable levels must proceed with a fasciotomy. Fasciotomy is the definitive treatment for chronic compartment syndrome, in which the orthopedic surgeon will open the affected compartment layers with a full fasciotomy or partial fasciotomy to decrease compartment pressure (Lutz, Goodenough, & Detmer, 1989).

The only conservative alternative to fasciotomy for chronic compartment syndrome is to decrease participation in sports (Hutchinson & Ireland, 1994). Non-surgical treatment may consist of physical therapy, orthotic devices, stretching programs, and diuretic use, providing little benefit to the patient (Lutz, Goodenough, & Detmer, 1989). However, surgical interventions in the anterior thigh are rare. This case study presents a student athlete with clinically diagnosed bilateral compartment syndrome of

the anterior thighs who did not find relief from conservative treatments but ultimately underwent fasciotomy to return to full participation.

Anterior Thigh Compartment Syndrome Recognition

Physical examination of chronic compartment syndrome is frequently unremarkable, especially if the patient is asymptomatic at the time of examination (Lutz, Goodenough, & Detmer, 1989). Patient history may describe pain with exercise, and worsening of symptoms as months and sporting seasons elapse. Patients may present symptoms of overuse injuries, for example, iliotibial band syndrome. Symptoms will gradually increase, even with conservative treatment. Exercise testing should be specific to the activity that presents symptoms. Tightness of the compartment by palpation may be present if pressures exceed 30-35 mmHg (Detmer, Sharpe, Sufit, & Girdley, 1985). However, low values have not been accepted as determinants for the need of surgical decompression (Matsen, Winquist, & Krugmire, 1980).

Hutchinson & Ireland (1994) describe seven symptoms that may be present with compartment syndrome, which he refers to as the seven P's. These symptoms include: pain, pressure, pain with stretch, paralysis, paraesthesia, diminished pulses, and pallor. Patients with chronic exertional compartment syndrome of the anterior thigh may experience some, if not all, of the symptoms listed previously. Cessation of the activity that causes pain is the only non-surgical alternative (Lutz, Goodenough, & Detmer, 1989). In the highly competitive sporting arena, cessation of activity is not an option. This study presents a student athlete with two years of eligibility remaining in her collegiate career. The student athlete chose fasciotomy to return to full participation.

Summary

Sports medicine personnel must be well trained in the assessment of injuries to the thigh. Thorough knowledge of the anatomy of the thigh, the compartment properties, and the symptoms associated with compartment syndrome are essential evaluative components of an accurate assessment of anterior thigh compartment syndrome. Once compartment syndrome is suspected, the student athlete should be referred to a physician and fasciotomy may be performed for relief of symptoms. Post-surgical treatments must be based upon individual needs.

Sports medicine personnel must stay current with the signs and symptoms associated with rare injuries. This case study will hopefully improve the clinical evaluation of chronic compartment syndrome of the anterior thigh in student athletes. The purpose of this project is to present the signs and symptoms associated with chronic compartment syndrome of the anterior thigh. In addition, providing this information may aid sports medicine health care workers in acquiring knowledge regarding chronic compartment syndrome of the anterior thigh.

SECTION 3

METHODS

Proper education in the recognition of chronic anterior thigh compartment syndrome may decrease time to diagnosis and ischemia associated with the injury. The purpose of this study is to present a unique case of chronic compartment syndrome which may aid in educating sports medicine professionals of the potential diagnosis and surgical outcome of chronic compartment syndrome of the anterior thigh. This chapter will be presented in three sections: participant, research design, and procedures. The case study will be compiled into an article for submission to the *Journal of Athletic Training* to target the athletic training audience with current information.

Participant

The proposed case study will focus on one female collegiate tennis player who was diagnosed with chronic bilateral compartment syndrome of the anterior thigh during the spring season of her sophomore year, 2004. The participant was chosen due to the rarity of cases diagnosed as chronic compartment syndrome of the anterior thigh. The participant was originally diagnosed with iliotibial band syndrome and later was reassessed with chronic compartment syndrome and treated accordingly. Due to the rarity of this injury, the student athlete was asked to participate in this study after the fasciotomy, prior to the start of her junior year. The student athlete voluntarily agreed to participate in this project and will complete a participation form upon human subjects approval (see Appendix B).

Research Design

The case study research design is descriptive in nature. The case study was chosen for three reasons. First, the case presented a single participant who underwent a unique surgery. Second, the case study is retrospective in nature, with the injury occurring months prior to the investigation of this study. Third, the qualitative nature of this study was chosen to create a better understanding of the rarity of this injury. The purpose is not to generalize the symptoms associated with anterior thigh compartment syndrome, but rather present the findings of one unique case of chronic compartment syndrome of the anterior thigh and the results of fasciotomy.

Procedures

This case study will retrospectively examine the student athlete's medical records as well as research and literature on compartment syndromes. The researcher will be responsible for collecting and reporting data for this study. The data will be collected from the student athlete's medical records and will be retrospectively reviewed to formulate information on the participant's injury, diagnosis, and treatment. The researcher will have access to the medical files through a signed statement from the subject, giving permission to obtain the medical files (see Appendix C).

After human subjects approval, medical records will be obtained with permission from the participant (see Appendix C). The team athletic trainer and team physician at the university were responsible for recording the initial and final assessment of the injury. All examinations, tests, and procedures were done within the team's medical group. The consent form will be sent to the team physician to request that all information pertaining

to the student athlete's compartment syndrome is received by the researcher. The requested records will include doctor's visit reports, operative reports, diagnostic reports, and physical therapy reports. Magnetic resonance imaging (MRI), bone scan, and compartment pressure testing will be included as diagnostic reports.

The reports will be compiled to create a timeline from the initial diagnosis, to surgical procedures, to the resolution of the participant's symptoms. Research of the literature is based on topics related to this study and will be compiled to further understand the topic of compartment syndromes and for discussion purposes. The research was derived from medical journals whose publications pertain to compartment syndromes. The criteria for the selection of articles are to describe the anatomical characteristics, evaluation, treatment, healing complications, and ultimate surgery for relief of symptoms. The journals of publication include, but are not limited to: *American Family Physician, Annales Chirurgiae et Gynaecologiae, Biomechanics, Medicine and Science in Sport and Exercise, Sports Medicine, The American College of Sports Medicine, The American Journal of Sports Medicine, and The Journal of Bone and Joint Surgery*. The journals, and previously researched articles, will aid the study and assist in assessing protocols once a timeline is compiled for chronic compartment syndrome of the anterior thigh. The timeline will begin with the initial diagnosis and end as the student athlete returns to full participation.

This case study is qualitative in nature and will require the use of triangulation and member checking. Triangulation is referred to as the use of more than one source of data to substantiate the researcher's conclusions (Thomas & Nelson, 2001).

Triangulation reduces the risk of chance associations and systemic biases, and allows for a better assessment of the generality of explanations developed (Maxwell, 1996). A more specific type of triangulation used in this case study is theory construction, which refers to the processing of information and the comparison of findings with past experiences (Thomas & Nelson, 2001). Triangulation is used in this study as a collaboration of previous research related to chronic compartment syndrome of the anterior thigh. This study will also be peer reviewed for accuracy. Therefore, two athletic trainers (mean age 26.5 ± 2.5 years) including the researcher will examine the medical records and discuss the timeline created.

Member checking is a source of feedback from the participant, auditor, and debriefers used in this study. Feedback is used to decrease the possibility of misinterpretation of the meaning or perspective of the participant's injury. Therefore, once the timeline and article is constructed, the participant (student athlete), auditor, and debriefers will be asked to review the document to validate analyses and conclusions. Inaccurate data will then be evaluated by the two athletic trainers and changed if warranted. Upon completion of the written document, it will be submitted to *The Journal of Athletic Training*.

Summary

The single subject case study presented is descriptive in nature and will extend and/or enhance knowledge pertaining to chronic exertional compartment syndrome of the anterior thigh. The researcher will be directly involved in the collection, compilation, and reporting of the data for this study. The data is compiled from the participant's

medical history files, literature research, subjective, and objective information regarding rehabilitation. Once all the data and literature is compiled into an article, this case study will be submitted for publication to the *Journal of Athletic Training*. Sports medicine personnel will have access to the study to aid in reviewing and expanding their knowledge of chronic compartment syndrome of the anterior thigh.

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APPENDIX A

AUTHOR'S GUIDE FOR THE *JOURNAL OF ATHLETIC TRAINING* SUBMISSION

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The mission of the *Journal of Athletic Training* is to enhance communication among professionals interested in the quality of health care for the physically active through education and research in prevention, evaluation, management, and rehabilitation of injuries.

SUBMISSION POLICIES

1. Online submission is preferred: www.jat.msubmit. *Net*

2. Submit 6 copies of the entire manuscript (including tables and figures) to *Journal of Athletic Training* Submissions, Hughston Sports Medicine Foundation, Inc, 6262 Veterans Parkway, PO Box 9517, Columbus, GA 31908–9517. A table is an editable item that needs to be typeset. The term ''figure'' refers to items that are not editable, either halftones (photographs) or line art (charts, graphs, tracings, schematic drawings), or combinations of the two.

3. All manuscripts must be accompanied by a letter signed by each author and must contain the following statements: ''This manuscript 1) contains original unpublished material that has been submitted solely to the *Journal of Athletic Training,* 2) is not under simultaneous review by any other publication, and 3) will not be submitted elsewhere until a decision has been made concerning its suitability for publication by the *Journal of Athletic Training.* In consideration of the NATA's taking action in reviewing and editing my submission, I the undersigned author hereby transfer, assign, or otherwise convey all copyright ownership to the NATA, in the event that such work is published by the

NATA. Further, I verify that I have contributed substantially to this manuscript as outlined in item #3 of the current Authors' Guide.'' By signing the letter, the authors agree to comply with all statements. Manuscripts that are not ccompanied by such a letter will not be reviewed. Accepted manuscripts become the property of the NATA. Authors agree to accept any minor corrections of the manuscript made by the editors.

4. The *Journal of Athletic Training* conforms to the International Committee of medical Journal Editors' Uniform Requirements for manuscripts Submitted to Biomedical Journals. Each author must be specifically identified in the published manuscript, in accordance with the Uniform Requirements for Manuscripts Submitted to Biomedical Journals: ''Authorship credit should be based only on 1) substantial contributions to conception and design, or acquisition of data, or analysis and interpretation of data; 2) drafting the article or revising it critically for important intellectual content; and 3) final approval of the version to be published. Conditions 1, 2, and 3 must all be met. Acquisition of funding, the collection of data, or general supervision of the research group, by themselves, do not constitute authorship.'' For additional information, please visit the ''Uniform Requirements'' website: http://www.icmje.org/index.html. The authorship form, which is available at www.journalofathletictraining.org, should be completed and submitted with each new manuscript. Contribution categories include conception and design; acquisition of data; analysis and interpretation of the data; drafting of the article; critical revision of the article for important intellectual content; final approval of the article; provision of study materials or patients; statistical expertise; obtaining of funding; administrative, technical, or logistic support; and collection &

assembly of data. (Categories borrowed with the permission of the *Annals of Internal Medicine.*) Contributors to the manuscript who do not qualify for authorship should be thanked in the Acknowledgments section.

5. Financial support or provision of supplies used in the study must be acknowledged. Grant or contract numbers should be included whenever possible. The complete name of the funding institution or agency should be given, along with the city and state in which it is located. If individual authors were the recipients of funds, their names should be listed parenthetically.

6. Authors must specify whether they have any commercial or proprietary interest in any device, equipment, instrument, or drug that is the subject of the article in question. Authors must also reveal if they have any financial interest (as a consultant, reviewer, or evaluator) in a drug or device described in the article.

7. For xperimental investigations of human or animal subjects, state in the ''Methods'' section of the manuscript that an appropriate institutional review board approved the project. For those investigators who do not have formal ethics review committees (institutional or regional), the principles outlined in the Declaration of Helsinki should be followed (41st World Medical Assembly. Declaration of Helsinki: recommendations guiding physicians in biomedical research involving human subjects. *Bull Pan Am Health Organ.* 1990;24:606–609). For investigations of human subjects, state in the ''Methods'' section the manner in which informed consent was obtained from the subjects. (Reprinted with permission of *JAMA* 1997;278:68, copyright 1997, American Medical Association.)

If informed consent was not required because the study was exempt, provide the reason for the exemption.

8. Signed releases are required to verify permission for the *Journal of Athletic Training* to 1) reproduce materials taken from other sources, including text, figures, or tables; 2) reproduce photographs of individuals; and 3) publish a Case Report. A Case Report cannot be reviewed without a release signed by the individual being discussed in the Case Report. Release forms can be obtained from the Editorial Office and from the *JAT* web page, or authors may use their own forms.

9. The *Journal of Athletic Training* uses a doubleblind review process. Authors should not be identified in any way except on the title page.

10. Manuscripts are edited to improve the effectiveness of communication between author and readers and to aid the author in presenting a work that is compatible with the style policies found in the *AMA Manual of Style,* 9th ed. (Williams & Wilkins), 1998. Page proofs are sent to the author for proofreading when the article is typeset for publication. It is important that they be returned within 48 hours. Important changes are permitted, but authors will be charged for excessive alterations.

11. Published manuscripts and accompanying work cannot be returned. Unused manuscripts will be returned if submitted with a stamped, self-addressed envelope.

STYLE POLICIES

12. Each page must be printed on 1 side of 8½-by-11-inch paper, double spaced, with 1-inch margins in a font no smaller than 10 points. Each page should include line counts to facilitate the review process. Do not right justify pages.

13. Manuscripts should contain the following, organized in the order listed below, with each section beginning on a separate page: a. Title page b. Acknowledgments c. Abstract and Key Words (first numbered page) d. Text (body of manuscript) e. References f. Tables (each on a separate page) g. Legends to figures h. Figures

14. Begin numbering the pages of your manuscript with the abstract page as #1; then, consecutively number all successive pages.

15. Units of measurement shall be recorded as SI units, as specified in the *AMA Manual of Style,* except for angular displacement, which should be measured in degrees rather than radians. Examples include mass in kilograms (kg), height in centimeters (cm), velocity in meters per second (m s21 or m/s), angular velocity in degrees per second (8 s21), force in Newtons (N), and complex rates (mL/kg per minute).

16. Titles should be brief within descriptive limits (a 16-word maximum is recommended). If a disability is the relevant factor in an article, the name of the disability should be included in the title. If a technique is the principal reason for the report, it should be in the title. Often both should appear.

17. The title page should also include the name, title, and affiliation of each author, and the name, address, phone number, fax number, and e-mail address of the author to whom correspondence is to be directed. No more than 4 credentials should be listed for each author. The ''ATC'' credential is under the copyright protection of the National Athletic Trainers' Association Board of Certification. Therefore, the proper listing of an additional state credential is ''ATC, LAT'' or ''ATR, LAT''.

18. A structured abstract of no more than 250 words must accompany all manuscripts. Type the complete title (but not the authors' names) at the top, skip 2 lines, and begin the abstract. Items that are needed differ by type of article. **Original Research** articles: Context, Objective, Design, Setting, Patients or Other Participants, Intervention(s), Main Outcome Measure(s), Results, Conclusions, and Key Words. **Literature Reviews**: Objective, Data Sources, Study Selection, Data Extraction, Data Synthesis, Conclusions, and Key Words. **Case Reports**: Objective, Background, Differential Diagnosis, Treatment, Uniqueness, Conclusions, and Key Words; **Clinical Techniques**: Objective, Background, Description, Clinical Advantages, and Key Words. For the Key Words entry, use 3 to 5 words that do not appear in the title. **Evidence-based Practice:** Reference/ Citation, Clinical Question, Data Sources, Study Selection, Data Extraction, Main Results, Conclusions, and Commentary.

19. Begin the text of the manuscript with an introductory paragraph or two in which the purpose or hypothesis of the article is clearly stated and developed. Tell why the study needed to be done or the article written and end with a statement of the problem (or controversy). Highlights of the most prominent works of others as related to your subject are often appropriate for the introduction, but a detailed review of the literature should be reserved for the discussion section. In a 1- to 2-paragraph review of the literature, identify and develop the magnitude and significance of the controversy, pointing out differences among others' results, conclusions, and/or opinions. The introduction is not the place for great detail; state the facts in *brief,* specific statements and reference them. The detail belongs in the discussion. Also, an overview of the manuscript is part of the abstract, not

the introduction. Writing should be in the active voice (for exJournal of Athletic Training **299** ample, instead of ''Subjects were selected,'' use ''We selected subjects'') and in the first person (for example, instead of ''The results of this study showed,'' use ''Our results showed'').

20. The body or main part of the manuscript varies according to the type of article (examples follow); however, the body should include a discussion section in which the importance of the material presented is discussed and related to other pertinent literature. When appropriate, a discussion subheading on the clinical relevance of the findings is recommended. Liberal use of headings and subheadings, charts, graphs, and figures is recommended. a. The body of an **Original Research** article consists of a methods section, a presentation of the results, and a discussion of the results. The methods section should contain sufficient detail concerning the methods, procedures, and apparatus employed so that others can reproduce the results. The results should be summarized using descriptive and inferential statistics and a few well-planned and carefully constructed illustrations. b. The body of a **Literature Review** article should be organized into subsections in which related thoughts of others are presented, summarized, and referenced. Each subsection should have a heading and brief summary, possibly one sentence. Sections must be arranged so that they progressively focus on the problem or question posed in the introduction. c. The body of a **Case Report** should include the following components: personal data (age, sex, race, marital status, and occupation when relevant—not name), chief complaint, history of present complaint (including symptoms), results of physical examination (example: ''Physical findings relevant to the

rehabilitation program were . . .''), medical history (surgery, laboratory results, examination, etc), diagnosis, treatment and clinical course (rehabilitation until and after return to competition), criteria for return to competition, and deviation from expectations (what makes this case unique). d. The body of a **Clinical Techniques** article should include both the *how* and *why* of the technique: a step-by-step explanation of how to perform the technique, supplemented by photographs or illustrations, and an explanation of why the technique should be used. The discussion concerning the *why* of the technique should review similar techniques, point out how the new technique differs, and explain the advantages and disadvantages of the technique in comparison with other techniques. e. The purpose of the **Evidence-Based Practice** section is to provide a short review of current scientific literature and to apply the findings to clinical athletic training practice. All articles submitted for this section should be concise reviews of published systematic reviews or meta-analyses on topics relevant to the 7 domains of athletic training (Prevention, Assessment/Evaluation, First Aid/Treatment, Rehabilitation, Organization/ Administration, Counseling, and Education). Reviews of individual, large, controlled clinical trials will also be considered. The review must begin with the complete article title and reference and a statement of the clinical question the review addresses. The rest of the review consists of a summary of the article and must include the following sections: data sources and search terms used; study selection (inclusion and exclusion) criteria; the methods used to extract and review data, including a list of the primary outcome measures; results of the search strategy; and primary outcome measures and conclusions. A separate commentary section should address the application of the

information to the clinical athletic training setting. Authors may use supplementary scientific literature (up to a maximum of 5 references) to support the commentary.

21. Percentages should be accompanied by the numbers used to calculate them. When reporting nonsignificant results, a power analysis should be provided.

22. **Communications** articles, including official Position Statements and Policy Statements from the NATA Pronouncements Committee; technical notes on such topics as research design and statistics; and articles on other professional issues of interest to the readership are solicited by the *Journal.* An author who has a suggestion for such a paper is advised to contact the Editorial Office for instructions.

23. The manuscript should not have a separate summary section—the abstract serves as a summary. It is appropriate, however, to tie the article together with a summary paragraph or list of conclusions at the end of the discussion section.

24. References should be numbered consecutively, using superscripted arabic numerals, in the order in which they are cited in the text. No more than 30 references should be cited in Original Research manuscripts. Literature Reviews are limited to 50 references. References should be used liberally. It is unethical to present others' ideas as your own. Also, use references so that readers who desire further information on the topic can benefit from your scholarship.

25. References to articles or books, published or accepted for publication, or to papers presented at professional meetings are listed in numerical order at the end of the manuscript. Journal title abbreviations conform to *Index Medicus* style. Examples of references are illustrated below. See the *AMA Manual of Style* for other examples.

Journals: 1. van Dyke JR III, Von Trapp JT Jr, Smith BC Sr. Arthroscopic management of postoperative arthrofibrosis of the knee joint: indication, technique, and results. *J Bone Joint Surg Br.* 1995;19:517–525. 2. Council on Scientific Affairs. Scientific issues in drug testing. *JAMA.*1987;257:3110–3114.

Books:

1. Fischer DH, Jones RT. *Growing Old in America.* New York, NY: Oxford University Press Inc; 1977:210–216.

2. Spencer JT, Brown QC. Immunology of in-fluenza. In: Kilbourne ED, Gray JB, eds. *The Influenza Viruses and Influenza.* 3rd ed. Orlando, FL: Academic Press Inc; 1975:373–393.

Presentations:

1. Stone JA. Swiss ball rehabilitation exercises. Presented at: 47th Annual Meeting and Clinical Symposia of the National Athletic Trainers' Association; June 12, 1996; Orlando, FL.

Videos:

1. *Spine Injury Management* [videotape]. Champaign, IL: Human Kinetics; 2001.

Software:

1. *SPSS Base for Windows* [computer program]. Version 11.0. Chicago, IL: SPSS Inc; 2001.

Internet Sources:

1. Knight KL, Ingersoll CD. Structure of a scholarly manuscript: 66 tips for what goes where. Available at http://www.journalofathletictraining.org/jat/66tips.

html. Accessed January 1, 1999. 2. National Athletic Trainers' Association. NATA blood borne pathogens guidelines for athletic trainers. Available at http:// www.journalofathletictraining.org. Accessed January 1, 1999.

26. Personal communications are cited in the text as follows: ''. . . (J.A. Smith, written communication, January 2003).'' The written or oral nature of the communication is stated, and the communication does not appear in the reference list. Authors must provide written permission from each personal-communication source. A form is available on the *JAT* Web site (www.journalofathletictraining.org) and from the Editorial Office.

27. Table Style: 1) Title is bold; body and column headings are roman type; 2) units are set above rules in parentheses; 3) numbers are aligned in columns by decimal; 4) footnotes are indicated by symbols (order of symbols: *, †, ‡, §, ZZ, ¶); 5) capitalize the first letter of each major word in titles; for each column or row entry, capitalize the first word only. See a current issue of the *Journal* for examples.

28. Figures may be submitted as electronic figures or as hard copies only. Figures submitted electronically should conform to the requirements as described on the *JAT* Web site (www.journalofathletictraining.org). However, 6 paper copies of each figure must also be provided with the initial submission. Figures submitted as hard copy must be in camera-ready form. Line art should be of good quality; should be clearly presented on white paper with black ink, sans serif typeface, and no box; and should be printed on a laser printer—no dot matrix. Figures that require reduction for publication must remain readable at their final size (either 1 column or 2 columns wide). Photographs should be glossy black and white prints. Do not use paper clips, write on photographs, or attach

photographs to sheets of paper. On the reverse of each figure attach a write-on label with the figure number, name of the author, and an arrow indicating the tip. (Note: Prepare the label before affixing it to the figure).

29. Authors must request color reproduction in a cover letter with the submitted manuscript. Authors will be notified of the additional cost of color reproduction and must confirm acceptance of the charges in writing.

30. Legends to figures are numbered with Arabic numerals in order of appearance in the text. Legends should be printed on separate pages at the end of the manuscript.

31. The *Journal of Athletic Training* follows the redundant publication guidelines of the Council of Science Editors, Inc (*CBE Views.* 1996; 19:76–77; also available on the *JAT* web site at www.journalofathletictraining.org). Authors found in violation of redundant publication will have sanctions invoked by the Journal Committee of the National Athletic Trainers' Association, Inc.

PUBLICATION POLICIES

32. Original Research manuscripts will be categorized under the following table of contents subheadings: clinical studies, basic science, educational studies, epidemiologic studies, and observational/informational studies. 33. Only Case Reports and Clinical Techniques that define and establish the optimal standard of care or the practice of athletic training will be considered for publication in *JAT.* All other Case Reports and Clinical Techniques will be considered for publication in the *NATA News.*

34. Media Reviews will appear in the *NATA News.*

APPENDIX B

CONSENT TO PARTICIPATE IN STUDY

Consent to Participate in Study

Agreement to Participate in Research

Responsible Investigator: Michelle Pikor
Title of Protocol: A Case Study: Anterior Thigh Compartment Syndrome of a Collegiate Female Tennis Player

1. I have been asked to participate in a research study investigating an injury that I sustained while participating in tennis at Santa Clara University. The injury that the research study will focus on is the bilateral fasciotomy of the anterior thigh compartments.

2. I grant the investigator access to all medical reports related to the fasciotomy of the anterior thigh compartments. The medical records will be kept secure at the researchers home and all identification on them that related them to me will be removed.

3. No risks are anticipated and no benefits are expected.

4. There will be no compensation awarded for participation.

5. The results of the study may be published but not information that could identify me will be included.

6. Any questions about the research may be addressed to Michelle Pikor at (408) 551-1767. Complaints or comments about the research may be presented to Leamor Kahanov, EdD, ATC and Greg Payne, P.E.D, project chair, at (408) 924-3028. Questions about the research, subject' rights, or research-related injury may be presented to Pam Stacks Ph.D. at (408) 924-2480.

7. I voluntarily give consent to participate in this study. I may refuse to participate in the study or in any part of the study. I am free to withdraw at any time without prejudice to my relations with Santa Clara University and I will not lose any services in which I am entitled.

8. I have received a signed and dated copy of the consent form.

_____ _____
Signature Date

_____ _____
Investigator's Signature Date

Consent to Participate in Study

Agreement to participate in Research

Responsible Investigator: Michelle Pikor
Title of Protocol: A Case Study: Anterior Thigh Compartment Syndrome of a Collegiate Female Tennis Player

1. I have been asked to participate in a research study investigating a case study as an advisor and/or debriefer of the data. The injury that the research study will focus on is the bilateral fasciotomy of the anterior thigh compartments.

2. No risks are anticipated and no benefits are expected.

3. There will be no compensation awarded for participation.

4. The results of the study may be published but not information that could identify me will be included.

5. Any questions about the research may be addressed to Michelle Pikor at (408) 551-1767. Complaints or comments about the research may be presented to Leamor Kahanov, EdD, ATC and Greg Payne, P.E.D, Project Chair, at (408) 924-3028. Questions about the research, subject' rights, or research-related injury may be presented to Pam Stacks Ph.D. at (408) 924-2480.

6. I voluntarily give consent to participate in this study. I may refuse to participate in the study or in any part of the study. I am free to withdraw at any time without prejudice to my relations with Santa Clara University and I will not lose any services in which I am entitled.

7. I have received a signed and dated copy of the consent form.

_____ _____
Signature Date

_____ _____
Investigator's Signature Date

APPENDIX C

MEDICAL RECORD RELEASE

To: Medical Records

From:_____

SSN:_____

DOB:_____

I, _____, Give SOAR Medical Center the right to release a copy of my entire medical file (From April, 2004 to Present) related to my bilateral compartment syndrome of the anterior thighs to Dr. Dillingham, team physician for Santa Clara University. Please include, but do not limit to, doctor reports, operation reports, X-rays, MRI's, compartment pressure testing procedures, and Bone Scans.

You can Fax them to: Dr. Michael Dillingham

Fax: (408) 551-1744

If you have any questions please do not hesitate to call _____. Thank you for your assistance and prompt attention to this request.

Sincerely,

_____